AD-A088 360 DAYTON UNIV OHIO F/G 14/2

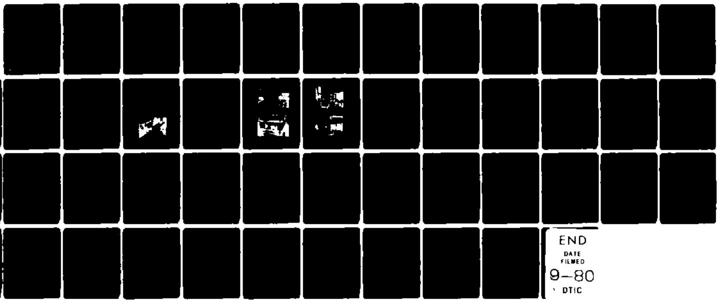
TRI-SERVICE THERMAL FLASH TEST FACILITY. SUMMARY REPORT.(U)

JAN 80 B H WILT, R A SERVAIS, N J OLSON DNA001-79-C-0106

UNCLASSIFIED UDR-TR-80-03 DNA-5197F NL

1 of 1

AD A 088360

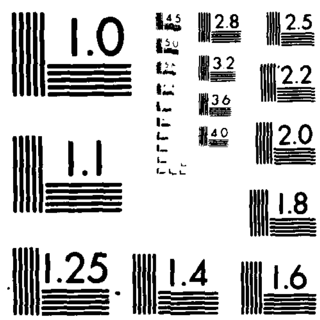


END

DATE FILMED

9-80

DTIC



MICROCOPY RESOLUTION TEST CHART

AD-E300876

(12) LEVEL II

DNA 5197F

AD A088360

TRI-SERVICE THERMAL FLASH TEST FACILITY

Summary Report

University of Dayton
Industrial Security Super KL-505
300 College Park Avenue
Dayton, Ohio 45469

15 January 1980

Final Report for Period 15 December 1978—15 December 1979

CONTRACT No. DNA 001-79-C-0106

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

THIS WORK SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER RDT&E RMSS CODE B342079464 N99QAXAJ50304 H2590D.

Prepared for

Director
DEFENSE NUCLEAR AGENCY
Washington, D. C. 20305

Destroy this report when it is no longer needed. Do not return to sender.

PLEASE NOTIFY THE DEFENSE NUCLEAR AGENCY, ATTN: TISI, WASHINGTON, D.C. 20305, IF YOUR ADDRESS IS INCORRECT, IF YOU WISH TO BE DELETED FROM THE DISTRIBUTION LIST, OR IF THE ADDRESSEE IS NO LONGER EMPLOYED BY YOUR ORGANIZATION.

18 DNA, SBIE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: DNA 5197F, AD-E300 876	2. GOVT ACCESSION NO.: AD-A088 360
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): TRI-SERVICE THERMAL FLASH TEST FACILITY. Summary Report.	5. TYPE OF REPORT & PERIOD COVERED: Final Report, ~~for Period~~ 15 Dec 78—15 Dec 79
	6. PERFORMING ORG. REPORT NUMBER: UDR-TR-80-03
7. AUTHOR(s): Benjamin H. Wilt, Forward A. Servais, Nicholas J. Olson	8. CONTRACT OR GRANT NUMBER(s): DNA 001-79-C-0106
9. PERFORMING ORGANIZATION NAME AND ADDRESS: University of Dayton, Industrial Security Super KL-505, 300 College Park Avenue Dayton, Ohio 45469	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Subtask N99QAXAJ503-04
11. CONTROLLING OFFICE NAME AND ADDRESS: Director Defense Nuclear Agency Washington, D.C. 20305	12. REPORT DATE: 15 January 1980
	13. NUMBER OF PAGES: 50
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 51	15. SECURITY CLASS (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B342079464 N99QAXAJ50304 H2590D.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Thermal Nuclear Flash
Radiation
Quartz Lamps
Thermal Radiation
Test Facility
Materials Response to Thermal Radiation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the status of the Tri-Service Thermal Nuclear Flash Test Facility. It describes the improvements in facility capabilities that were incorporated during the past 12 months to enhance thermal flash simulation. The report also summarizes all tests for the continuation of a comprehensive data base.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

1 Ø 3 E 5 9

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

PREFACE

This summary report covers work performed during the period from 15 December 1978 to 15 December 1979 under Defense Nulcear Agency Contract DNA001-79-C-0106. The work was administered under the direction of Capt. J. M. Rafferty, Contracting Officer's Representative on this contract. The contract represents a follow-on effort to Defense Nuclear Agency Contract DNA001-76-C-0339 under which the following reports were generated:

UDRI-TR-77-28, "Tri-Service Thermal Radiation Test Facility: Test Procedures Handbook," May 1977.

DNA 4488Z, "Tri-Service Thermal Flash Test Facility," Interim Summary Report, 29 March 1978.

DNA 4757F, "Tri-Service Thermal Flash Test Facility," Final Report for Period 6 August 1976-31 October 1978, 30 November 1978.

The work was conducted under the general supervision of Mr. Dennis Gerdeman and the principal investigator was Mr. Benjamin H. Wilt. Dr. Ronald A. Servais acted as consultant and the research technician was Mr. Nicholas J. Olson.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 1
INTRODUCTION

1.1 BACKGROUND

The University of Dayton has a long history of involvement in materials development and testing. Since the 1950's, the University has performed testing and evaluation of materials exposed to high thermal inputs. These efforts in support of the United States Air Force have included the development and operation of appropriate laboratory facilities.

In 1976, the Defense Nuclear Agency contracted with the University of Dayton Research Institute to establish and operate a thermal nuclear flash simulation facility for conducting tests of materials for the Tri-Service community. During the initial one-year contract effort and a one-year contract extension, the facility was established and 3,235 thermal flash tests were conducted. During the 12-month follow-on contract period from December 1978 to December 1979, an additional 3,336 exposures were completed.

The data accumulated through materials exposure to the intense thermal radiation of the thermal flash facility can be utilized by design engineers to match material performance with design criteria and by computer simulation engineers as a data base for verification of computer modeling techniques.

1.2 OBJECTIVES

The primary objectives of the research activity can be summarized:

(1) To continue to provide the Tri-Service community with a quick-response intense radiation heating experimental capability, including the effects of aerodynamic and mechanical loads;

(2) To conduct tests for the Tri-Service community as required; and

(3) To maintain, improve, and modify the test facility between scheduled tests.

SECTION 2
TRI-SERVICE NUCLEAR FLASH TEST FACILITY

2.1 OVERVIEW

The original development of the Tri-Service Nuclear Flash Test Facility is described in Reference 1. The Facility has four basic experimental capabilities at the present time:

(1) Irradiation of test specimens using a Quartz Lamp Bank (QLB);

(2) Irradiation of test specimens using a QLB in aerodynamic flow;

(3) Irradiation of test specimens using a QLB with tension or bending mechanical loads; and

(4) Irradiation of test specimens using an Arc Imaging Furnace (AIF).

The Facility layout is illustrated in Figure 1.

Available instrumentation include radiometers for determining heat flux, thermocouples for monitoring temperature, a pitot tube for determining flow velocities, strain gages, still and movie cameras, X-Y recorders, and various electronic control devices. Limited machining facilities are available for minor specimen modification or alteration during test programs.

2.2 NUCLEAR FLASH SIMULATION

2.2.1 Quartz Lamp Banks

The degradation of materials exposed to the radiant heating generated by a nuclear blast can very enormously. The intense radiation needed to simulate a nuclear flash can be produced by a series or bank of tungsten filament, quartz lamps. Three banks are available in the Facility; they are designed the Stationary Quartz Lamp Bank (SQLB), the Mobile Quartz Lamp Bank (MQLB), and the High Density Lamp Bank (HDLB). The operational characteristics of the banks are listed in Table 1. The SQLB is

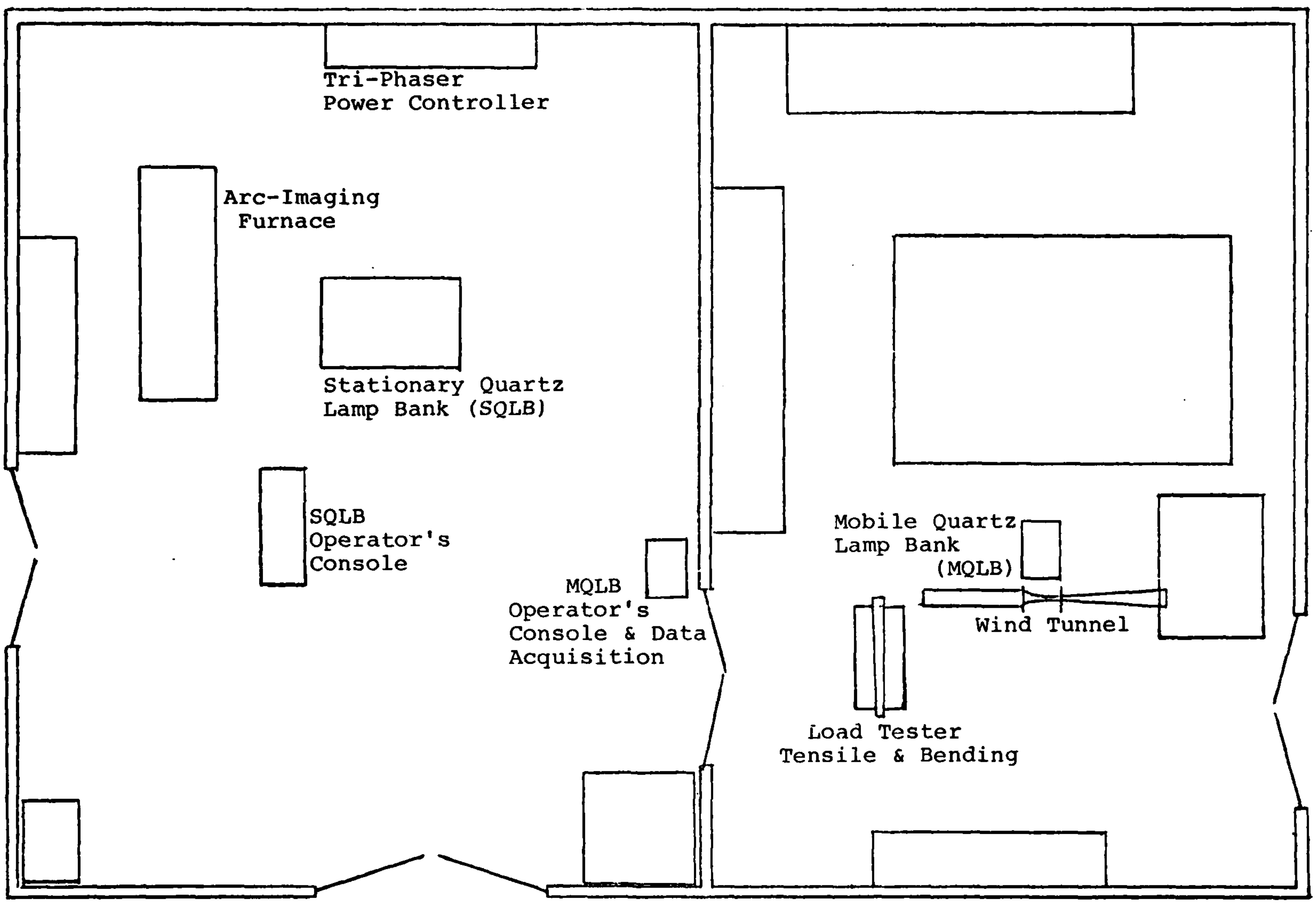


Figure 1. Tri-Service Nuclear Flash Test Facility.

TABLE 1

QUARTZ LAMP BANK SPECIFICATIONS

	SQLB	MQLB	HDLB
Lamp Designation	GE/Q6M/T3/CL/HT	GE/Q6M/T3/CL/HT	GE/Q6M/T3/CL/HT
Number of Lamps	24	24	24
Lamp Bank Area	22 cm x 25 cm	22 cm x 25 cm	15 cm x 25 cm
Maximum Voltage	460 vac	460 vac	460 vac
Maximum Current	300 a	300 a	300 a

primary used for instrumentation check-out and radiation-only exposure tests. The MQLB, shown in Figure 2, is used in conjunction with the simulation of aerodynamic or mechanical loads.

The MQLB approximates a one-dimensional radiation source 15 cm x 12 cm; the HDLB, shown in Figure 3, approximates a 10 cm x 12 cm one-dimensional source. The incident radiation on a test specimen is a function of the distance from the bank source, as illustrated in Figure 4. It is also a function of the area of uniform exposure. Also indicated in Figure 4 is the heat flux distribution for the MQLB to a larger test area provided by a new wind tunnel test section. The new test section (70 cm TS) is fully described in paragraph 2.3.

With the incorporation of the new test section the maximum heat flux level using the MQLB has been increased from approximately 40 cal/cm^2-sec to 62 cal/cm^2-sec. The HDLB, capable of attaining 57 cal/cm^2-sec when used with the original test section, has not yet been adapted to the new test section.

2.2.2 Arc Imaging Furnaces

Two arc imaging furnaces are available. The furnace specifications are given in Table 2. Both utilize carbon arcs

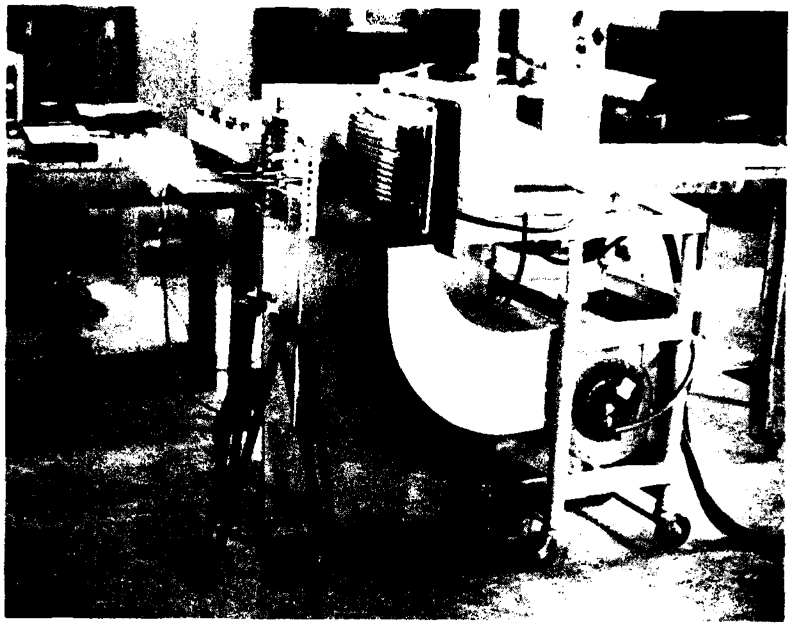


Figure 2. Mobile Quartz Lamp Bank.

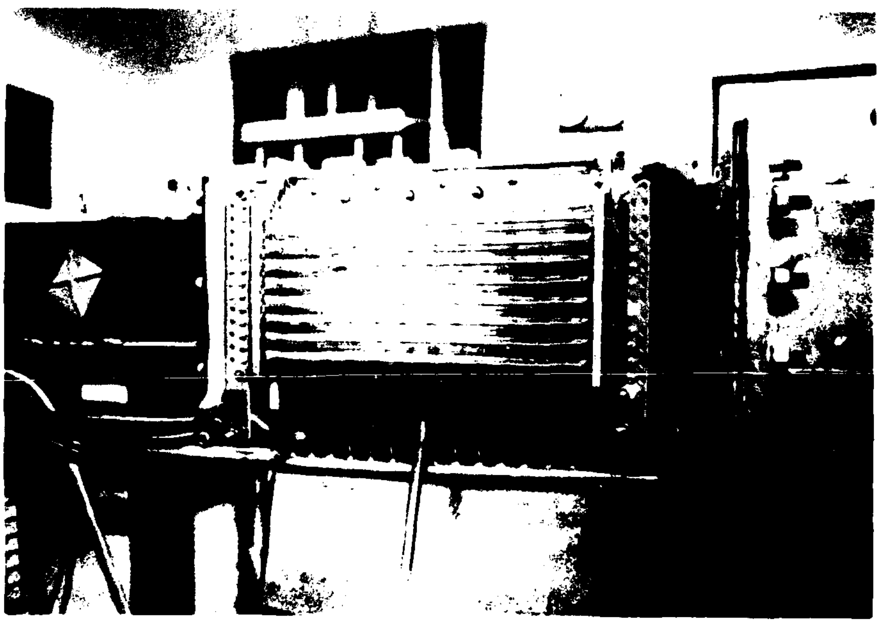


Figure 3. High Density Lamp Bank.

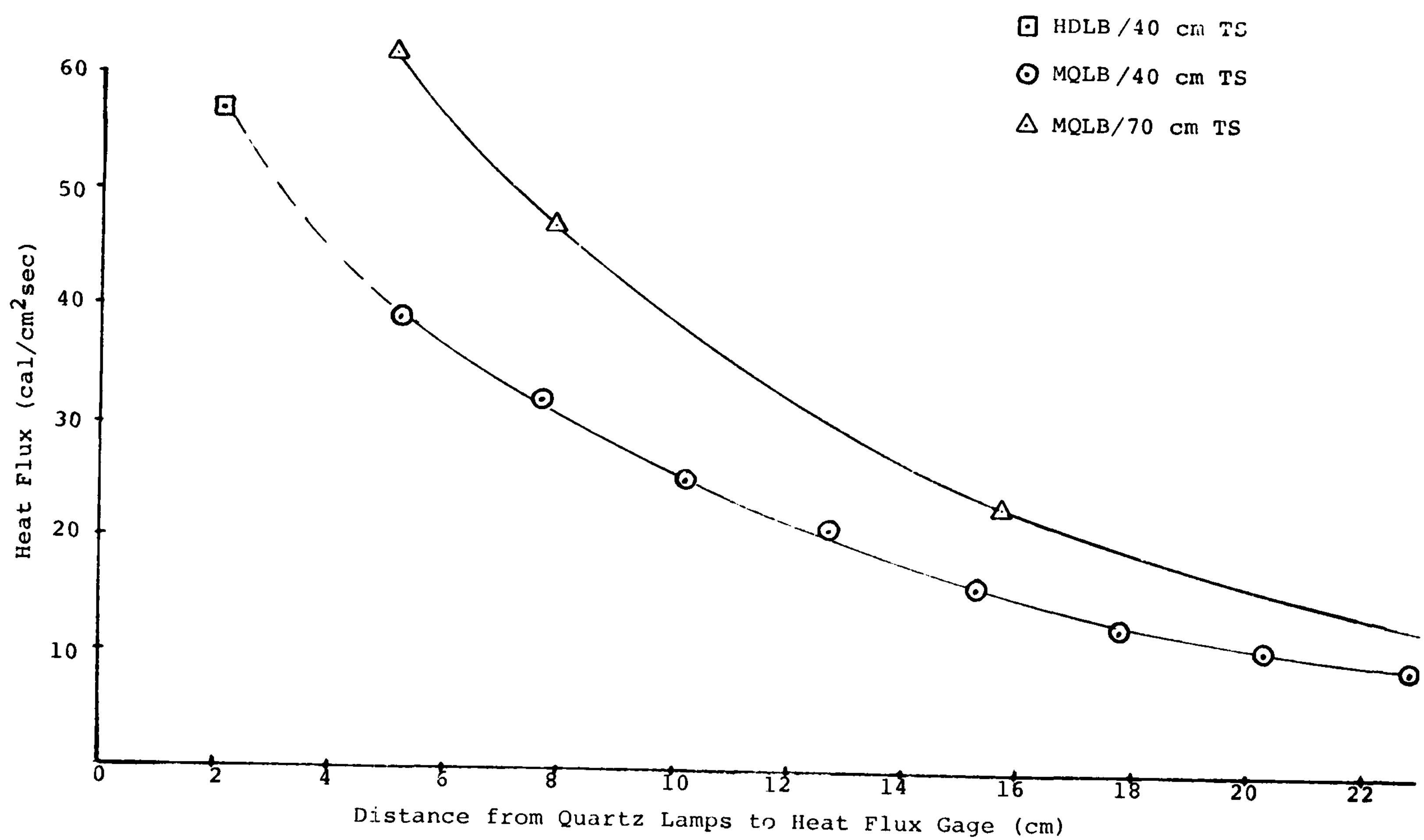


Figure 4. Radiation Heat Flux vs. Distance From Lamp Bank.

TABLE 2

ARC IMAGING FURNACE SPECIFICATIONS

Mfgr.	Model	Beam	Arc Power
Strong	66000-2	Gaussian	72 vdc, 160a
Genarco	T-ME 6-CWM	One-dimensional	75 vdc, 420a

as radiation sources, thereby producing a different wavelength radiation than produced by the tungsten filament quartz lamps.

The Gaussian Beam Arc Imaging Furnace (GBAIF) is capable of producing a radiant heat flux up to about 140 cal/cm^2-sec. Two parabolic mirrors are used to reflect the beam from the arc and to refocus the beam on the test specimen. Different peak intensities are achieved by de-focusing the beam. Typical specimen sizes are on the order of 2.5 cm x 2.5 cm square or 2.5 cm in diameter; usually a special mounting bracket is designed for each type of specimen in order to minimize heat losses. Exposure times may vary from 0.1 second to about 20 seconds; the time is accurately controlled by a water-cooled shutter, thereby producing a square wave profile in time. Arc voltage and current are monitored during testing to insure that the heat flux remains constant.

The One-Dimensional Beam Arc Imaging Furnace (ODBAIF) uses one mirror to produce an essentially parallel light radiation test device. The ODBAIF has not been checked out at this time. The beam diameter is expected to be about 30 cm with a constant heat flux of 1 cal/cm^2-sec. The heat flux-to-area ratio can be used to estimate the flux for smaller diameter exposure areas. A shutter is used to produce a square wave profile, similar to the GBAIF. The ODBAIF will not be brought on-line until an appropriate test requirement becomes available; approximately two man-months will be required to bring it to operational status.

2.3 AERODYNAMIC LOAD SIMULATION

An open-circuit pull-down wind tunnel is available to simulate aerodynamic flow over specimens exposed to high intensity radiation. The wind tunnel is shown in Figure 5 and photographs of both the original and the new wind tunnel test sections are shown in Figures 6 and 7, respectively. The test section in Figure 6 is a 40 cm long test section (40 cm TS) having 2.38 cm x 11.43 cm cross-sectional area. The constant freestream velocity is nominally 240 m/sec; the nominal Mach number is 0.7. The Reynolds number based on the inlet wall length can be varied from 2×10^6 to 18×10^6.

The new test section in Figure 7 is a 70 cm long test section (70 cm TS) having the same cross-sectional area. The constant freestream velocity for the elongated section is nominally 210 m/sec with a corresponding Mach number of 0.6. The Reynolds number is 20×10^6 based on the inlet wall length.

A pitot probe, manometers, and a pressure transducer are available for flow calibration, which can be supplied with each test program, as required.

The MQLB or the HDLB is used in conjunction with the wind tunnel; the beam is brought in through a quartz window which is mounted in one wall of the test section. The opposite wind tunnel test section wall holds the test specimen, which is mounted flush with the wind tunnel wall. Specimen sizes up to 11.43 cm by 10.08 cm can be accommodated in the 40 cm TS. Specimen sizes of up to 22.86 cm by 10.08 cm can be accommodated in the 70 cm TS. Special plates are available for each test section for mounting the various calorimeters and pitot tube for heat flux and flow calibration. Heat flux levels of up to 57 cal/cm^2-sec are readily attained with the HDLB/40 cm TS configuration and, at present, up to 62 cal/cm^2-sec with the MQLB/70 cm TS configuration. Exhaust gases are vented to the atmosphere through the roof of the building.

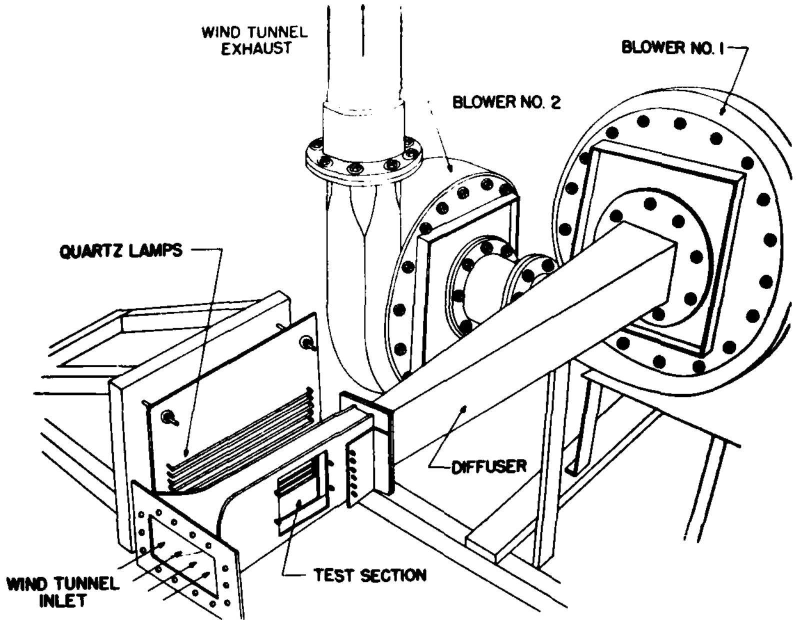


Figure 5. Wind Tunnel.

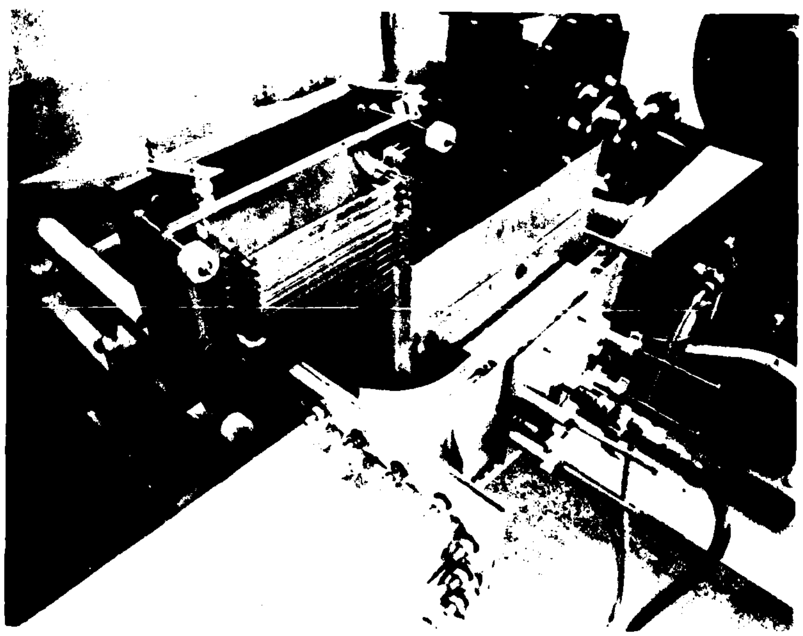


Figure 6. Wind Tunnel 40 cm Test Section.

2.4 SHUTTER DEVELOPMENT

An electronically actuated shutter for the wind tunnel test configuration represented a first priority improvement on the contract effort. A shutter was designed and installed in the 40 cm test section during February 1979. The shutter was installed along the centerline of the modified test section to take advantage of the convective cooling provided by the tunnel air flow. Lamp-to-specimen distance and, therefore, maximum heat flux available were not affected by the installation. The rapid rise and accurately controlled pulse attained with the shutter capability enhances simulation of thermal nuclear heating.

Because of minor problems of warping of the shutter in the modified 40 cm test section, the new, heavier stainless steel test section described in paragraph 2.3 was designed. The elongated 70 cm test incorporated larger window and specimen exposure areas as well as improved shutter concepts. A photograph depicting shutter operation in the 70 cm test section is shown in Figure 8.

2.5 MECHANICAL LOAD SIMULATION

A creep frame is available for dead weight simulation of tensile and bending loads and is shown in Figure 9. The MQLB is used as the radiation source; the exposure procedure is similar to that used in the wind tunnel. Note that mechanical and aerodynamic loads cannot be applied simultaneously at time time. Tension and bending configurations are possible. Three and four point bending is accomplished in the mechanical load frame by the addition of a yoke and fulcrum as indicated in Figure 10. Recommended specimen sizes and maximum applied loads are specified in Table 3. Strain gages and other appropriate instrumentation are mounted on test specimens in order to monitor strain as a function of time during exposure to radiation.

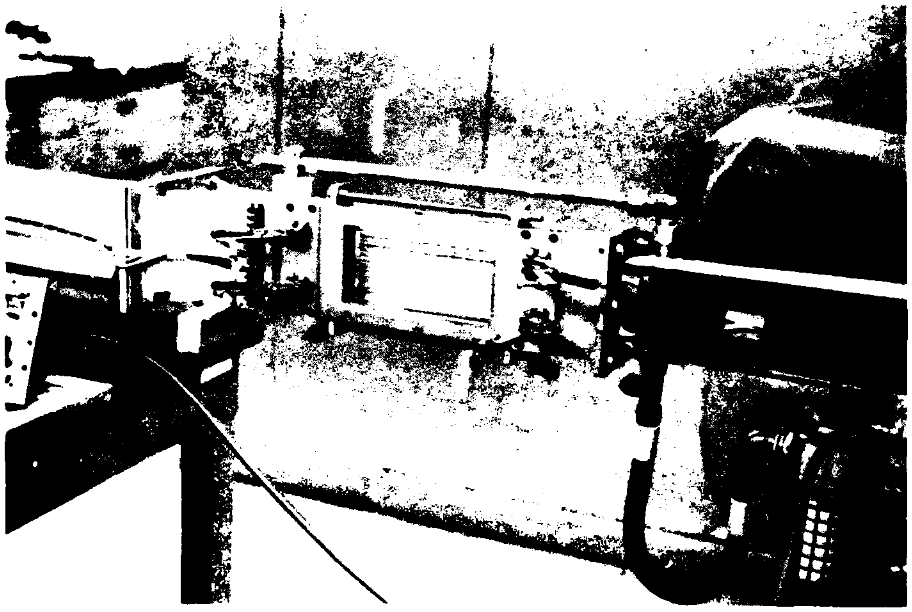


Figure 7. Wind Tunnel 70 cm Test Section.

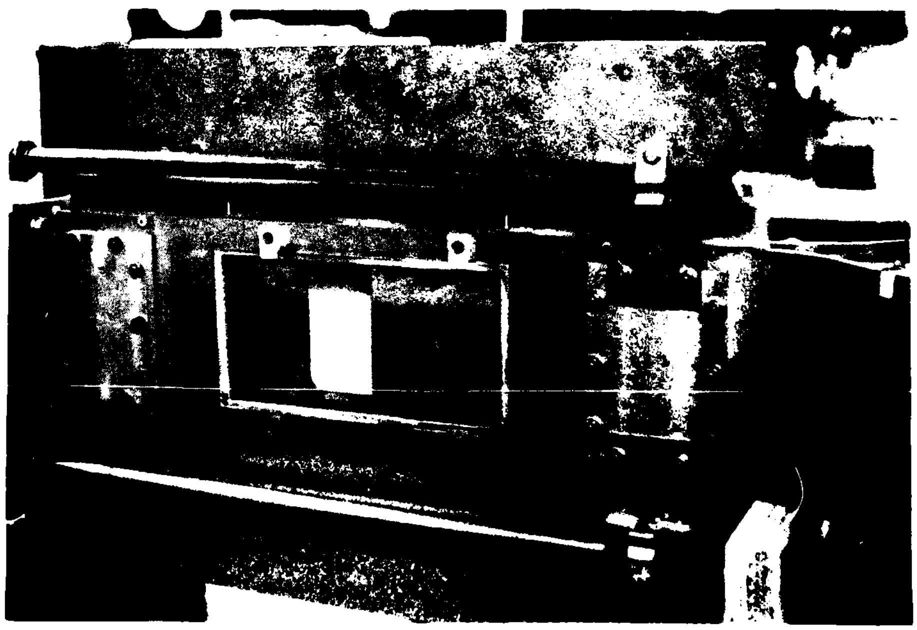


Figure 8. 70 cm Test Section Shutter.

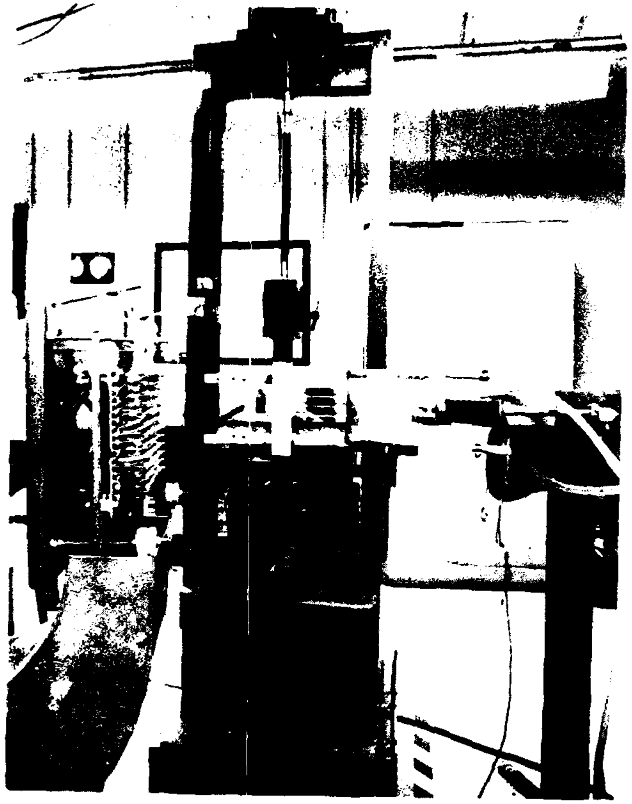


Figure 9. Mechanical Loading-Tension.

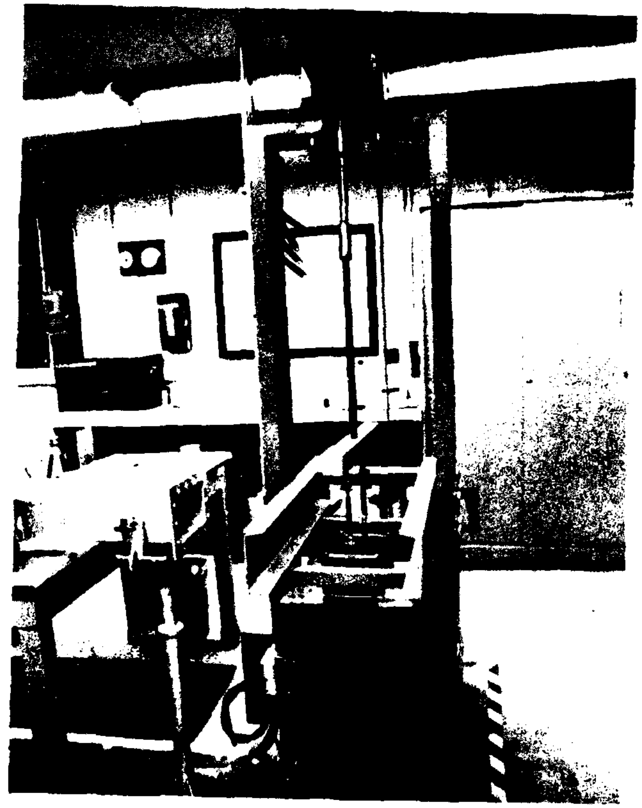


Figure 10. Mechanical Loading-Bending.

TABLE 3

RECOMMENDED MECHANICAL LOADING SPECIMEN INFORMATION

	Uniaxial Tension	Bending Tension or Compression
Specimen Size (cm)		
Width	5-7.5	5-7.5
Thickness	0.02-1.25	0.6-2.5
Length	25-60	50-75
Stress Levels (MPa)	3.5-1700	7-1400

2.6 INSTRUMENTATION

The instrumentation required for operating the facility and which is available is summarized in Table 4. Facility users normally supply their own specimen-mounted instrumentation, such as thermocouples and strain gages. Additional details on the heat flux instrumentation and plotters which are available are given in Tables 5 and 6.

2.7 DATA ACQUISITION SYSTEM

The data acquisition system, including an LSI-11 micro-computer, is capable of producing conventional X-Y plots on-line or transmitting the digitized calibration or property data directly to the Wright-Patterson Air Force Base (WPAFB) Computing Facility for further data reduction. The output can be in the form of tabulated or plotted and labelled data. Figure 11 schematically illustrates the system. Table 7 lists the system components. The interface between the LSI-11 and the WPAFB Computing Facility was developed by Lt. Randy Rushe and is described in Reference 2.

2.8 CONTROL SYSTEM

The primary components of the laboratory (quartz lamp banks, wind tunnel, exhaust system) can be controlled and monitored from the operator console, which is shown in Figure 12.

TABLE 4

AVAILABLE INSTRUMENTATION

Application	Quantity	Instrumentation	Purpose
Quartz Lamp Banks	6	Radiometers	Heat Flux
	1	Thermac Temperature Controller	Heat Flux Control
	1	Data-Trak Controller	Heat Flux Control
Aerodynamic Load	1	±10 psi Stathem pressure Transducer	Flow Calibration
	1	Pitot Probe Assembly	Flow Calibration
	1	Manometer	Flow Calibration
Mechanical Load	1	Wheatstone Bridge	Strain Gage
Arc Imaging Furnaces	2	Radiometers	Heat Flux
	1	Calorimeter	Heat Flux
	1	Time Controller (0.1 sec/min)	Shutter Control
General	3	X-Y-Y' Recorders	Data Recording
	1	Kennedy DS-370 Tape Recorder	Data Recording
	1	LSI-11 Microprocessor	Data Recording
	1	35mm Nikon Still Camera	Specimen Photographs
	1	MP-4 Polaroid Still Camera	Specimen Photographs
	2	8mm Nizo Braun Movie Cameras	Specimen Photographs
	-	Various Thermocouples	Temperature
	1	L&N 8641-S Automatic Recording Pyrometer (760-6,000°C)	Surface Temperature
	-	Barometer, Thermometer, Hygrometer	Ambient Conditions

TABLE 5

HEAT FLUX GAGE SPECIFICATIONS

Mfgr	Type	Model	Range	Accuracy
Medtherm	Gardon	64P-20-24	0-5 cal/cm^2sec	$\pm 3\%$
Medtherm	Gardon	64P-50-24	0-13 cal/cm^2sec	$\pm 3\%$
Medtherm	Gardon	64P-100-24	0-27 cal/cm^2sec	$\pm 3\%$
Medtherm	Gardon	64P-100-24	0-27 cal/cm^2sec	$\pm 3\%$
Medtherm	Gardon	64P-200-24	0-54 cal/cm^2sec	$\pm 3\%$
Medtherm	Gardon	64P-200-24	0-54 cal/cm^2sec	$\pm 3\%$
RdF	Gardon	CFR-1A	0-400 cal/cm^2sec	$\pm 10\%$
RdF	Gardon	CFR-1A	0-400 cal/cm^2sec	$\pm 10\%$
ADL	Calorimeter	---	50-350 cal/cm^2sec	$\pm 5\%$

TABLE 6

X-Y RECORDER SPECIFICATIONS

Mfgr	Model	Channels	Range	Response
Hewlett-Packard	7046A X-Y-Y'	2	0.2mv/cm-4v/cm	0.025-5cm/sec
Hewlett-Packard	136 X-Y-Y'	2	0.2mv/cm-20v/cm	0.05-5cm/sec
Honeywell	540 X-Y-Y'	2	0.04mv/cm-0.4v/cm	0.025-5cm/sec

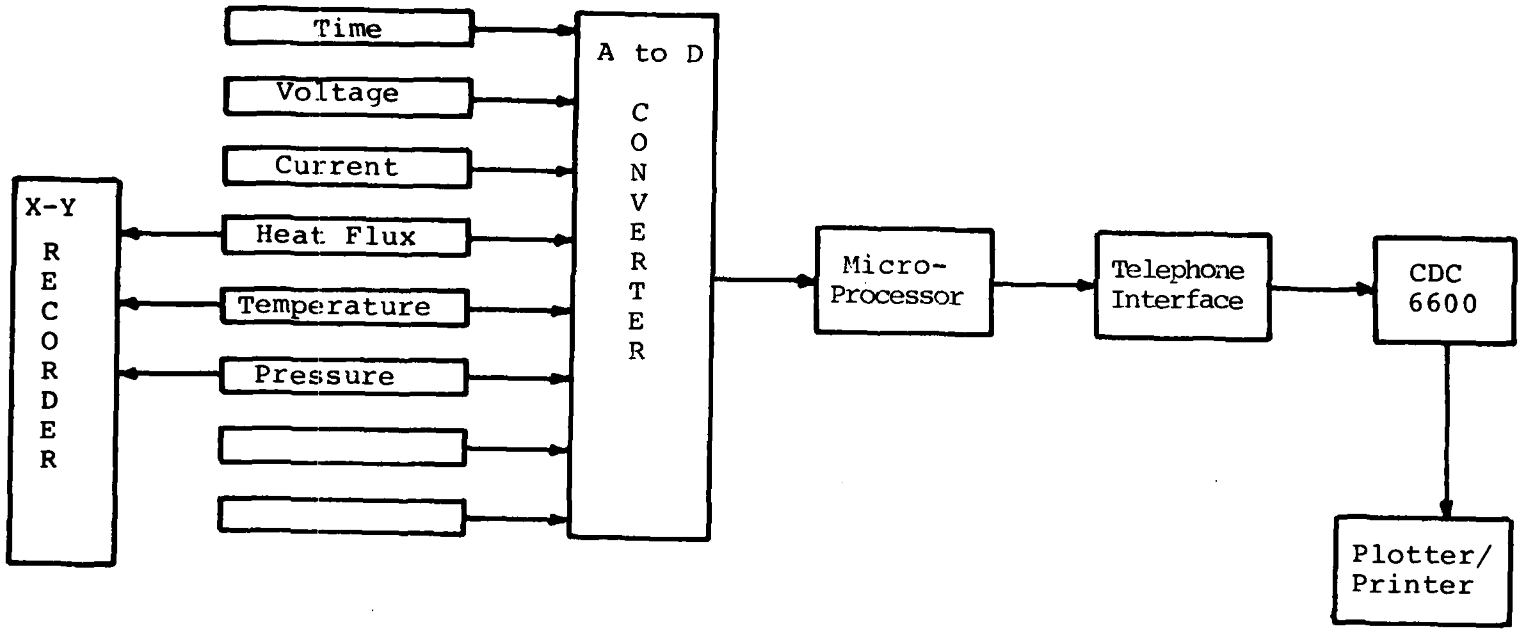


Figure 11. Data Acquisition System.

TABLE 7

DATA ACQUISITION SYSTEM COMPONENTS

<u>Operating Controls</u>
Wind tunnel operation
Quartz lamp operation
Quartz lamp cooling operation (blower & air)
Quartz lamp remote operation jack
Quartz lamp & shutter exposure time control
Computer reset, clock & hold operation
Controller set-point remote operation
Tri-phaser controller
<u>Monitoring Controls</u>
Quartz lamp power - voltage & current indicators
Wind tunnel pressure indicator
Peripheral equipment temperature indicator (10 pt.)
Shutter solenoid overheat indicator
Quartz lamp cumulative operating time indicator
<u>Data Acquisition</u>
LSI-11 microprocessor
Ectron differential D.C. amplifiers (8)
Power supply
Teletype
Acoustic coupler

Only one operator is required for most tests. The console is mobile and located such that the operator can visually observe a test (if appropriate) and also monitor critical voltages and currents, etc. This allows the operator to abort a test if necessary. The console also houses the microcomputer and the other components of the data acquisition system with the exception of the data terminal. Figure 13 is an overview of the mobile quartz lamp bank, the wind tunnel, and the operating console.

2.9 COMPUTER MODELING

A two-dimensional thermal response computer program for predicting the thermal response of materials exposed to intense thermal radiation and aerodynamic cooling in the Tri-Service Thermal Flash Test Facility was developed by William N. Lee at Kaman AviDyne under contract to the Defense Nuclear Agency. The analysis and operating procedures are described in detail in Reference 3.

2.10 RELATED THERMAL FLASH TESTING

Under the authorization of DNA, Mr. Nicholas Olson of UDRI traveled to Kirtland AFB, New Mexico, on two separate occasions in July 1979 to both assist and observe Thermal Flash Bag nuclear simulation testing. From 8 July to 13 July, Mr. Olson assisted in the installation of thermocouple and copper slug calorimeter instrumentation on selected sections of a B-52 aircraft. He also assisted in the installation of several other components including coated aluminum specimens hand-carried by Mr. Olson from the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio.

The Thermal Flash Bag radiant thermal source consisted of 16 polyethylene bags charged with a mixture of oxygen and aluminum powder. The bags were placed within the periphery of the strategically placed specimens. The actual test involved ignition of powdered aluminum/oxygen mixture and observation of the thermal response of the instrumented materials.

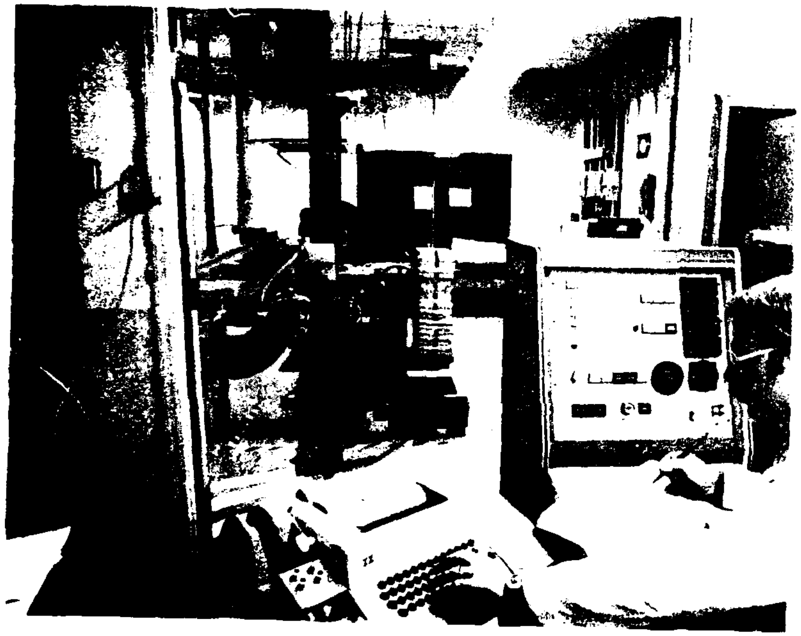


Figure 12. Console.

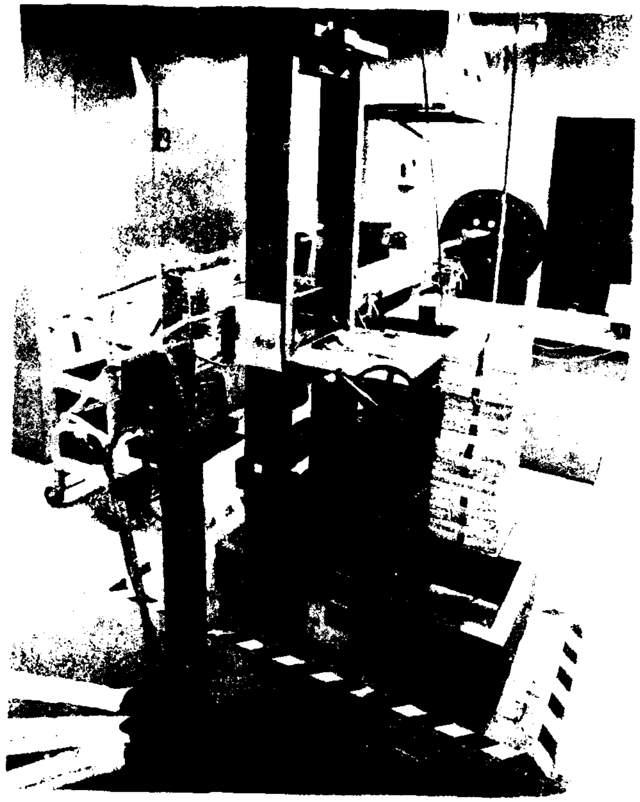


Figure 13. Thermal Flash Laboratory Overview.

Mr. Olson performed similar functions during a second visit from 22 to 26 July. In addition, he attended several meetings with representatives from Government and industry to discuss the methodology and validity of thermal nuclear flash simulation.

SECTION 3
FACILITY UTILIZATION

3.1 TEST SCHEDULING

The Tri-Services Nuclear Flash Test Facility is available to governmental users on a no-charge basis. Test programs involving nuclear thermal flash materials performance receive priority although other tests may be accommodated; all test programs must be approved by the Defense Nuclear Agency contract monitor.

Specific details regarding test program procedures, scheduling, special testing requirements, specimen sizes, heat flux levels, etc., should be directed to the Principal Investigator and Test Director in charge of the Facility, Mr. Ben Wilt (513-229-2517). Note that the analysis of material performance must be conducted by the Facility user.

Material response tests for the Tri-Service community take precedence over all other activities associated with the operation of the Facility. That is, test requests have been scheduled at the test initiator's convenience if possible. Since most test programs are about one to five days in length, few conflicts in scheduling have arisen and few are anticipated. Based on experience, each new test program typically requires special planning and hardware (such as instrumentation and specimen mounting brackets); therefore, the more advance notice given for a particular test program the more efficiently the tests can be conducted. All test scheduling, special requirements, etc., have been and will be handled by the Test Director, Mr. Ben Wilt.

3.2 COMPLETED TEST PROGRAMS

The primary purpose of the Facility is to support the Tri-Service community with a quick-response, thermal nuclear flash, materials response testing capability. Tests which have

been conducted are summarized in Table 8. Additional information on these tests can be obtained by contacting Mr. Ben Wilt and References 4-8. The specific runs are listed in the Appendix.

3.3 PROJECTED TEST PROGRAMS

Table 9 identifies the known tests to be conducted during the next 12 months. Since the primary purpose of the Facility involves quick-response testing, it is not possible to establish a comprehensive list of all future tests at this time.

TABLE 8

COMPLETED AND CURRENT TEST PROGRAMS

Initiator	Org.	Project	Test No.	Test Dates
Alexander	AVCO	DNA	001-073	March 7-10, 1977
Alexander	AVCO	DNA	074-086	March 15, 1977
Collis	Boeing	AWACS	087-316	March 21-24, 1977
Graham	AVCO	DNA	359-416	June 6-16, 1977
Alexander	Boeing	DNA	419-574	June 20-24, 1977
Collis	AVCO	ALCM	576-677	July 19-22, 1977
Alexander	AVCO	DNA	678-772	Oct. 5-7, 1977
Grady	AFML	DNA	773-870	Oct. 12-22, 1977
Litvak	AFML	B-1	Documentary Film	March 13-24, 1978
Collis	Boeing	ALCM	871-1076	July 18-20, 1978
Sparling	Rockwell	DNA	1081-2571	July 24-Sept. 28, 1978
Worscheck	GD-Convair	ALCM	2572-2677	Oct. 2-4, 1978
Olson	UDRI	Calibration	2678-2710	Oct. 16-20, 1978
Sparling	Rockwell	DNA	2711-5753	Oct. 24-Dec. 5, 1978
Alexander	AVCO	DNA	5754-5809	Dec. 11-13, 1978
Baba	Harry Diamond	U.S. Army	5810-5881	Dec. 18-21, 1978
Olson	UDRI	Calibration	5882-5890	Jan. 22, 1979
Evans	Ballistics Research	U.S. Army	5891-5948	Jan. 23-24, 1979
Spangler	MCDAC	DNA	5949-6032	March 6-15, 1979
Rooney	AFML	USAF	6033-6036	March 19, 1979
Spangler	MCDAC	DNA	6037-6056	April 2, 1979
Worscheck	GD-Convair	ALCM	6057-6074	May 2, 1979
Kimerly	LATA	DNA	6075-6096	May 31-June 1, 1979
Alexander	AVCO	DNA	6097-6140	June 19-21, 1979
Baba	Harry Diamond	U.S. Army	6141-6222	June 25-27, 1979

TABLE 8 (Concluded)

COMPLETED AND CURRENT TEST PROGRAMS

Initiator	Org.	Project	Test No.	Test Dates
Schmitt	AFML	USAF	6223-6247	June 28-29, 1979
Kimerly	LATA	DNA	6248-6264	July 2-3, 1979
Worscheck	GD-Convair	ALCM	6265-6307	July 17-19, 1979
Spangler	MCDAC	DNA	6308-6372	July 30-Aug. 2, 1979
Schmitt	AFML	USAF	6373-6423	Aug. 14-16, 1979
Schmitt	AFML	USAF	6424-6426	Aug. 30, 1979
Worsheck	GD-Convair	ALCM	6427-6435	Sept. 4, 1979
Schmitt	AFML	USAF	6436-6438	Oct. 3, 1979
Alexander	AVCO	DNA	6439-6449	Oct. 5-10, 1979
Olson	UDRI	DNA	6450-6466	Oct. 15-19, 1979
Rooney	AFML	USAF	6467-6470	Nov. 11, 1979
Kimerly	LATA	DNA	6471-6480	Dec. 4-6, 1979
Etzel	Aerojet-General	DNA	6481-6555	Dec. 10-13, 1979
Kimerly	LATA	DNA	6556-6561	Dec. 14, 1979

TABLE 9

PROJECTED TEST PROGRAMS

Initiator	Organization	Project	Material	Date
Etzel	Aerojet General	DNA	Aircraft Composites	January 1980
Rhodehamel	AFML	USAF	Graphite Epoxies	January 1980
Alexander	AVCO	DNA	Aircraft Composites	January 1980
Etzel	Aerojet General	DNA	Aircraft Composites	January 1980
Schmitt	AFML	USAF	Aircraft Composites	February 1980
Baba	Harry Diamond	U.S. Army	Camouflage Coatings	February 1980
Etzel	Aerojet General	DNA	Aircraft Composites	February 1980
Walsh	Boeing-Wichita	USAF	Aircraft Composites	March 1980
Etzel	Aerojet General	DNA	Aircraft Composites	March 1980
Etzel	Aerojet General	DNA	Aircraft Composites	April 1980
Etzel	Aerojet General	DNA	Aircraft Composites	May 1980
Etzel	Aerojet General	DNA	Aircraft Composites	June 1980
Etzel	Aerojet General	DNA	Aircraft Composites	July 1980

SECTION 4
PROJECT FACILITY DEVELOPMENT

4.1 FACILITY MAINTENANCE AND IMPROVEMENTS

Keeping the facility operational and current is an ongoing activity which is carried out between scheduled tests. Maintenance typically involves quartz lamp replacement, periodic calibration of instrumentation, and related activities.

Each new test program seems to extend the previous capability of the facility. This includes additional instrumentation, higher heat flux levels, etc. In order to accommodate future requirements, the time between scheduled tests and maintenance activities is devoted to facility upgrading. These improvements are all directed toward improving the quality of the data or extending the basic facility capabilities. The improvements are implemented by the staff as time permits, most requiring staff time rather than additional hardware purchases. The recommended improvements are listed below, categorized by priority.

4.1.1 First Priority Improvements

Dynamic Load Capability - Modifications to the present static load (tension and bending) test frame should be undertaken to provide simultaneous thermal and dynamic stresses for materials evaluation. This represents a major modification to the present facility.

Surface Phenomena Photography - Motion picture photography of surface degradation would be an asset to data analysis. Although this procedure is relatively straightforward, proper placement of equipment with thermal protection and the choice of lenses and filters is critical. Redesign and fabrication of the wind tunnel test section and improved quartz lamp installation now make this improvement feasible.

Surface Temperature Pyrometry - Physical constraints in placement of a recording pyrometer have been lessened with

the use of the new wind tunnel test section. Lack of definition of response characteristics of the quartz lamps still inhibit accurate temperature sensing capabilities.

4.1.2 Second Priority Improvements

Quartz Lamp Wavelength Response - Spectral scanning techniques are required for the accurate determination of quartz lamp wavelength. Absorptivity, reflectivity, and transmissivity characteristics of materials evaluated in the thermal flash environment cannot accurately be determined without wavelength definition.

Test Specimen Absorptivity - An experimental method for determining the absorptivity of test materials as a function of wavelength should be developed.

SECTION 5
SUMMARY

The Tri-Services Thermal Nuclear Flash Test Facility for investigating the effects of thermal radiation on materials has been established. The Facility is located at the U.S. Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio. The capability for irradiating specimens to intense thermal radiation, including the effects of aerodynamic loads or mechanical loads is operational. Three thousand two hundred thirty-five (3,235) tests have been conducted for the Tri-Service community at this time. A large number of additional tests are scheduled during the next 12 months; additional improvements to the Facility are planned, with an emphasis on photographing specimen deterioration during the exposure to intense radiation heating.

REFERENCES

1. Servais, R. A., Wilt, B. H., and Olson, N. J., "Tri-Service Thermal Flash Test Facility," Interim Summary Report, DNA 4488Z, 29 March 1978.

2. Rushe, R., "A Microcomputer Data Acquisition System for Materials Testing," Master of Science Thesis submitted to the Air Force Institute of Technology, March 1978.

3. Lee, W. N., "TRAP-ML-A Two Dimensional Thermal Response Code Tailored for the Defense Nuclear Agency Tri-Service Thermal Radiation Test Facility," DNA 4770F, 30 November 1978.

4. Scherer, W. R. and Collis, S. E., "Nuclear Thermal Suvivability/Vulnerability of the E-4B," Boeing Aerospace Co. Rpt. No. D226-20380-1, March 1977.

5. "Skin Friction Drag Increase Due to Nuclear Thermal Damage," Boeing Aerospace Co. Final Report on Contract DNA001-77-C-0090, 30 September 1977.

6. Collis, S. E., "Simulated Nuclear Thermal Testing of AGM-86 Honeycomb Sandwich Structures," Boeing Aerospace Co. Rpt. No. D232-10599-3, November 1977.

7. Alexander, J. G., "Conductive Coatings for Composite Aircraft Surfaces," AVCO Systems Division, Rpt. No. AFML-TR-77-164, September 1977.

8. Collis, S. E., "Simulated Nuclear Thermal Testing of AGM-86 Nosecap Sandwich Structure and Fin/Elevon Graphite-Epoxy Composites," Boeing Aerospace Co. Rpt. (to be published).

APPENDIX

THERMAL FLASH TESTS

Run Series	Specimen Configurations: Substructures	Coatings
001-073	Aluminum 6061	WMS-0; WMS-4; WMS-7; CMS-905; WMS-0/CMS-905; WMS-4/CMS-905; WMS-7/CMS-905; 1224-0; CMS-6231
	Glass-Epoxy	WMS-0/CMS-905; WMS-7/CMS-905; CMS-905; CMS-6231
	Graphite-Epoxy	WMS-0/CMS-905; WMS-4/CMS-905; WMS-7/CMS-905; 1224-4/CMS-905; 1224-0; CMS-905
074-086	Graphite-Epoxy	WMS-0; WMS-4; WMS-7/CMS-905; WMS-7/CMS-6231; CMS-6231
087-316	Glass-Epoxy Honeycomb	MIL-C-8326; MIL-L-81352; MIL-C-83281; MIL-C-83286; Astrocoat; Fluorocarbon; Polysulfide
	Aluminum Honeycomb	MIL-C-8326; MIL-C-83286
	Graphite-Epoxy TBD Honeycomb	MIL-C-83281; MIL-C-83286
	Aluminum Sheet	MIL-C-83281; MIL-C-83286
	Magnesium Sheet	MIL-C-83281; MIL-C-83286
317-360	FACILITY MODIFICATION AND CALIBRATION	
361-412	Quartz Polyimide	Uncoated
	Graphite-Epoxy	Uncoated
419-574	Glass-Epoxy	1; 2; 3; 4A; 4B; 5A; 5B; 5C; 5D; 6; 7; 8A; 8B; 8C; 9; 9B; 10; 11; 12A; 12B; 13A; 13B; 15A; 15B; 16; 17 (Table I)
	Graphite-Epoxy	1; 2; 3; 4; 5; 5B; 5C; 6; 7; 8B; 9A; 9B; 10; 11; 12A; 12B; 13A; 13B; 15A; 16; 17 (Table I)
	Quartz Polyimide	1; 2; 3; 4A; 4B; 5A; 5B; 5C; 5E; 9A; 10; 12A; 15A; 15B; 16; 17 (Table I)
	Aluminum 6061	2; 6; 7; 12; 18; 19; 20; 21 (Table I)

APPENDIX (Continued)

THERMAL FLASH TESTS

Run Series	Specimen Configurations Substructures	Coatings
575-677	Glass-Epoxy Honeycomb	25; 26; 28; 29; 30; 31; 32; 33 (Table I)
	Aluminum Honeycomb	25; 26; 27 (Table I)
	Aluminum Sheet	25; 26; 27 (Table I)
688-772	Glass-Epoxy	1; 2; 3; 4B; 5A; 5B; 5C; 5D; 7; 9A; 10; 10B; 15A; 24 (Table I)
	Graphite-Epoxy	4B; 6; 9A; 9C; 10; 10B; 10C; 11A; 12A; 12C; 12D; 14; 15B; 22; 23 (Table I)
	Quartz Polyimide	0; 4B; 5; 5B; 5C; 9A; 10A; 10B; 12A; 12C; 12D; 14; 15A (Table I)
773-855	Graphite-Epoxy	White polyimide; cork silicone; uncoated (All tested in tension)
	Quartz Polyimide	White polyimide; cork silicone; uncoated (All tested in tension)
856-870	Aluminum	Grey polymeric bead
871-1076	Epoxy-fiberglass Foam sandwich	34; 35; 36 (Table I)
	Epoxy-fiberglass Honeycomb sandwich	35; 37 (Table I)
	Graphite-epoxy	38; 39; 40 (Table I)
	Natural polyethylene with honeycomb core	No coating
	White polyethylene with honeycomb core	No coating
	Delrin with Flexcore Honeycomb	No coating
	Nylon with Flexcore Honeycomb	No coating

APPENDIX (Continued)

THERMAL FLASH TESTS

Run Series	Specimen Configurations: Substructures	Coatings
1081-2571	Honeycomb Substructure	41; 42; 43; 44; 45; 46; 47; 48; 49; 50; 51; 52; 53; 54 (Table I)
2572-2677	Aluminum 7075	55; 56; 57; 58; 59; 60; 61; 62; 63; Anodize (Table I)
	Glass-Epoxy	55; 56; 57; 58; 59; 60; 61; 62; 63; Uncoated (Table I)
2678-2710	FACILITY MODIFICATION AND CALIBRATION	
2711-5753	Honeycomb Substructure	41; 42; 43; 44; 45; 46; 47; 48; 49; 50; 51; 52; 53; 54 (Table I)
5754-5809	Graphite-Epoxy	1; 2; 3; 4A; 4B; 5A; 5B; 6; 10A; 10B; 10C; 14; 15A; 15B; 16; 17 (Table I)
	Quartz Polyimide	1; 2; 3; 4A; 4B; 5A; 5B; 6; 10A; 10B; 10C; 14; 15A; 15B; 16; 17 (Table I)
5810-5881	Fiber Optics	64; 65; 66; 67; 68 (Table I)
	Twisted Pair and Coaxial Electrical Cables	64; 65; 66; 67; 68 (Table I)
5882-5890	FACILITY CALIBRATION	
5891-5948	1060 Cold Rolled Steel	69; 70; 71; 72; 73; 74; 75; 76; 77; 78 (Table I)
5949-6032	Kevlar-Epoxy	79; 80; 81; 82; 83; 84; 85; 86; 87; 88; 89; 90; 91; 92; 93; 94 (Table I)
	Motorcase	79; 80; 81; 82; 83; 84; 85; 86; 87; 88; 89; 90; 91; 92; 93; 94 (Table I)
6033-6036	Aluminized Fabric	No coating
6037-6056	Vamac	No coating
	Viton	No coating

APPENDIX (Continued)

THERMAL FLASH TESTS

Run Series	Specimen Configurations Substructures	Coatings
6057-6074	Aluminum	55; 56; 57; 58; 59; 60; 61; 62; 63 (Table I)
	Epoxy/Fiberglass	55; 56; 57; 58; 59; 60; 61; 62; 63 (Table I)
6075-6096	Polypropylene	No coating
6096-6140	Graphite-Epoxy	1; 2; 3; 4A; 4B; 5A; 5B; 6; 10A; 10B; 10C; 14; 15A; 15B; 16; 17 (Table I)
	Quartz Polyimide	1; 2; 3; 4A; 4B; 5A; 5B; 6; 10A; 10B; 10C; 14; 15A; 15B; 16; 17 (Table I)
6141-6222	Fiber Optics	64; 65; 66; 67; 68 (Table I)
	Twisted Pair and Coaxial Electrical Cables	64; 65; 66; 67; 68 (Table I)
6223-6247	Aluminum	95; 96; 97; 98; 99; 100; 101; 102; 103; 104; 105 (Table I)
6248-6264		106; 107; 108; 109 (Table I)
6265-6307	Aluminum	55; 56; 57; 58; 59; 60; 61; 62; 63 (Table I)
	Epoxy/Fiberglass	55; 56; 57; 58; 59; 60; 61; 62; 63 (Table I)
	Polycarbonate	55; 56; 57; 58; 59; 60; 6o; 62; 63 (Table I)
	Quartz-Epoxy	55; 56; 57; 58; 59; 60; 61; 62; 63 (Table I)
6308-6372	Vamac	No coating
6373-6426	Aluminum	110; 111; 112; 113; 114; 115; 116; 117; 118; 119; 120; 121; 122; 123; 124 (Table I)
6427-6435	Teflon-Epoxy	55; 56 (Table I)

APPENDIX (Concluded)

THERMAL FLASH TESTS

Run Series	Specimen Configurations Substructures	Coatings
6436-6438	Epoxy/Fiberglass	125 (Table I)
6439-6449	Quartz Polyimide	4A; 4B (Table I)
6450-6466	FACILITY CALIBRATION	
6467-6470	Aluminized Tape	No coating
6471-6480	FACILITY CALIBRATION	
6481-6555		126; 127; 128; 129; 130; 131; 132; 133 (Table I)
6556-6561	FACILITY CALIBRATION	
6562-6598	Aluminum	95; 96; 97; 98; 99; 100; 101; 102; 103; 104; 105; 110; 111; 112; 113; 114; 115; 116 (Table I)

TABLE I

TABLE OF MATERIALS

1	Two-layer anti-static white polyurethane
2	Single-layer aluminized polyurethane
3	White MIL-C-83286 over aluminized polyurethane
4A	Dow 808 white silicone, 50 PVC titania
4B	Dow 808 white silicone, 25 PVC titania
5A	Three layer white fluorocarbon, 40 PVC titania plus fibers
5B	Three layer white fluorocarbon, 25 PVC titania plus fibers
5C	Three layer fluorocarbon erosion coating, 25 PVC titania plus fibers
5D	Three layer fluorocarbon erosion coating, 40 PVC titania plus fibers
6	Bonded copper foil, 2 Mil
7	Flame sprayed aluminum
8A	Bonded polyester film, 10 Mil
8B	Bonded TFE teflon film, 10 Mil
8C	Bonded UHMW polyethylene film, 10 Mil
9A	Bonded cork silicone, 20 Mil
9B	Bonded cork silicone, 50 Mil
9C	Cork silicone, 10 Mil
10A	Epoxy-polyimide white ablative paint
10B	Epoxy-polyimide flexible white, 6 Mil
10C	Epoxy-polyimide flexible white, 10 Mil
11	Grafoil stitched package
12A	Bonded RTV 655 silicone, 20 Mil
12B	Bonded RTV 655 silicone, 50 Mil
12C	Modified RTV 655, white, sprayed, 10 Mil
12D	Modified RTV 655, white, sprayed, 3 Mil
13A	Bonded silastic 23510 white silicone, 20 Mil
13B	Bonded silastic 23510 white silicone, 50 Mil
14	RTV-655, 3 Mil over cork silicone, 10 Mil
15A	134/KHDA polyurethane erosion coating, 5 PVC titania
15B	134/KHDA polyurethane erosion coating, 25 PVC titania

TABLE I

TABLE OF MATERIALS (Continued)

16	Desoto 10A grey polyurethane topcoat over aluminized polyurethane
17	Bostic dark grey polyurethane over aluminized polyurethane
18-21	Grey polyurethane
22	White RTV 655, 3 Mil over conductive RTV 3 Mil
23	Bonded aluminum foil, 2.4 Mil
24	Bonded aluminum foil with topcoat, 2.4 Mil
25	MIL-P-23377 primer plus white MIL-C-83286 enamel (Desoto)
26	Same as "25" except thicker enamel
27	Same as "25" except very thick enamel
28	Astrocoat system; primer plus white 8001 erosion coating plus white (non-yellowing) 8004 topcoat
29	Same as "28" but the 8001 coating is thicker
30	Astrocoat system; primer plus white (non-yellowing) 8004 topcoat
31	Astrocoat system; primer plus white 8001 erosion coating plus black 8003 antistatic topcoat
32	Same as "31" except thicker 8001 coating
33	Same as "25" except DEFT white enamel per MIL-C-83286
34	2-ply 120 fabric prepreg
35	2-ply 181 fabric prepreg
36	3-ply 181 fabric prepreg
37	5-ply 120 fabric prepreg
38	5-ply skin with chopped fiber-epoxy
39	2-ply skin with chopped fiber-epoxy

TABLE I

TABLE OF MATERIALS (Continued)

40	5-ply skin with chopped graphite fiber bonded to titanium
41	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 7781 glass reinforced F-161 epoxy (3, 4, 5, and 6 plies)
42	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 7781 glass reinforced CE-9000 epoxy (3, 4, 5, and 6 plies)
43	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 7781 glass reinforced F-178 addition polyimide (3, 4, 5, and 6 plies)
44	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 7781 glass reinforced 2272 addition polyimide (3, 4, 5, and 6 plies)
45	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 581 quartz reinforced F-161 epoxy (3, 4, 5, and 6 plies)
46	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 581 quartz reinforced F-178 addition polyimide (3, 4, 5, and 6 plies)
47	MIL-C-83286 white polyurethane, MIL-P-83277 primer over T-300 graphite reinforced 5208 epoxy (3, 4, 5, and 6 plies)
48	MIL-C-83286 white polyurethane, MIL-P-83277 primer over AS graphite reinforced 3501-5A epoxy (3, 4, 5, and 6 plies)
49	MIL-C-83286 white polyurethane, MIL-P-83277 primer over AS graphite reinforced 934 epoxy (3, 4, 5, and 6 plies)
50	MIL-C-83286 white polyurethane, MIL-P-83277 primer over AS graphite reinforced F-178 addition polyimide (3, 4, 5, and 6 plies)
51	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 181 Kevlar reinforced 5208 epoxy (3, 4, 5, and 6 plies)
52	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 181 Kevlar reinforced F-161 epoxy (3, 4, 5, and 6 plies)
53	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 181 Kevlar reinforced 934 epoxy (3, 4, 5, and 6 plies)
54	MIL-C-83286 white polyurethane, MIL-P-83277 primer over boron-epoxy (3, 4, 5, and 6 plies)

TABLE I

TABLE OF MATERIALS (Continued)

55	MIL-P-23377 primer
56	MIL-C-81773 coating 37875 over MIL-P-23377 primer
57	MIL-C-81773 coating 36622 over MIL-P-23377 primer
58	MIL-C-81773 coating 36314 over MIL-P-23377 primer
59	MIL-C-81773 coating 17875 over MIL-P-23377 primer
60	MIL-C-83286 coating 30140 over MIL-P-23377 primer
61	Mask 10A over MIL-P-23377 primer
62	Mask 10A over MIL-C-81773 coating 17875 over MIL-P-23377 primer
63	Mask 10A over MIL-C-81773 coating 37875 over MIL-P-23377 primer
64	Polyethylene
65	Polyurethane
66	Teflon
67	Polyvinylchloride
68	Rubber
69	Army Systems Camouflage MIL-E-52798A over TTP-636 primer
70	Army Systems Camouflage MIL-E-52835A over TTP-636 primer
71	Army Systems Camouflage MIL-E-52929 over TTP-636 primer
72	Army Systems Camouflage MIL-E-52909 over TTP-636 primer
73	Army Systems Camouflage MIL-E-52926 over TTP-636 primer
74	Army Systems Camouflage MIL-E-52798A over TTP-664 primer
75	Army Systems Camouflage MIL-E-52835A over TTP-664 primer
76	Army Systems Camouflage MIL-E-52929 over TTP-664 primer
77	Army Systems Camouflage MIL-E-52909 over TTP-664 primer
78	Army Systems Camouflage MIL-E-52926 over TTP-664 primer

TABLE I

TABLE OF MATERIALS (Continued)

79	Vamac 25-1.5, 2.5, and 3.5 mm thick
80	Viton 2B12-1.5, 2.5, and 3.5 mm thick
81	Vamac, 0.635 mm over Vamac-Silica, 2.865 mm
82	Vamac-Silica, 3.5 mm thick
83	NBR, 3.5 mm thick
84	Motorcase, 4.2 mm over motorcase, 7.7 mm
85	Vamac, 2.5 mm over Vamac Foam, 1.0 mm
86	Vamac, 2.5 mm over Light Vamac Foam, 1.0 mm
87	Vamac, 1.5 mm over Vamac Foam, 2.0 mm
88	Viton, 2.5 mm over Viton Foam, 1.0 mm
89	Viton, 1.5 mm over Viton Foam, 2.0 mm
90	Viton, 2.5 mm over Light Viton Foam, 1.0 mm
91	Low carbon Vamac, 3.5 mm
92	Low resistivity Vamac, 3.5 mm
93	KPN
94	White Viton over Viton, 2.0 mm
95	IR Silicone Camouflage, Black, F1
96	IR Silicone Camouflage, Green, F2
97	IR Silicone Camouflage, White, F3
98	IR Silicone Camouflage, Yellow, F4
99	IR Silicone Camouflage, Blue, F5
100	IR Silicone Camouflage, White, F6
101	IR Silicone Camouflage, Yellow, F7
102	IR Silicone Camouflage, Red, F8

TABLE I

TABLE OF MATERIALS (Continued)

103	IR Silicone Camouflage, Black, F9
104	IR Silicone Camouflage, Yellow, F10
105	IR Silicone Camouflage, Yellow, F11
106	Vamac 25
107	Vamac 1 and 2
108	Vamac (GD 151)
109	Royacril 1
110	IR Silicone Camouflage, White, F12-F15
111	IR Silicone Camouflage, Green, F16
112	IR Silicone Camouflage, Black, F17
113	IR Silicone Camouflage, Green, F18
114	IR Silicone Camouflage, Green, F19
115	IR Silicone Camouflage, Blue, F20
116	IR Silicone Camouflage, Blue, F21
117	IR Silicone Camouflage, Grey, F22-F25
118	IR Silicone Camouflage, Green, F26
119	IR Silicone Camouflage, Lt. Green, F27
120	IR Silicone Camouflage, Tan, F28
121	IR Silicone Camouflage, Grey, F29
122	IR Silicone Camouflage, Tan, F30
123	IR Silicone Camouflage, Black, F31
124	IR Silicone Camouflage, Dk. Green, F32-33

TABLE I

TABLE OF MATERIALS (Concluded)

125	Polyurethane, CAAP
126	Vamac 25, Lab
127	Vamac 25, PP2-B
128	Vamac 25, PP2-E
129	Vamac 25, PP2-B/Sp
130	Vamac 25, PP2-E/Sp
131	Vamac 25, Lab/Sp
132	Vamac 32, Lab
133	Vamac 32, PP2-B

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Assistant to the Secretary of Defense
Atomic Energy
ATTN: Executive Assistant

Defense Intelligence Agency
ATTN: DB-4C, V. Fratzke

Defense Nuclear Agency
ATTN: SPAS
ATTN: STSP
4 cy ATTN: TITL

Defense Technical Information Center
12 cy ATTN: DD

Field Command
Defense Nuclear Agency
ATTN: FCPR
ATTN: FCT, W. Tyler

Field Command
Defense Nuclear Agency
Livermore Division
ATTN: FCPRL

NATO School (SHAPE)
ATTN: U.S. Documents Officer

Undersecretary of Defense for Rsch. & Engrg.
ATTN: Strategic & Space Systems (OS)

DEPARTMENT OF THE ARMY

Harry Diamond Laboratories
Department of the Army
ATTN: DELHD-N-P, J. Gwaltney

U.S. Army Ballistic Research Labs
ATTN: DRDAR-BLT, J. Keefer
ATTN: DRDAR-BLT, W. Taylor

U.S. Army Materiel Dev. & Readiness Command
ATTN: DRCDE-D, L. Flynn

U.S. Army Nuclear & Chemical Agency
ATTN: Library

DEPARTMENT OF THE NAVY

Naval Material Command
ATTN: MAT 08T-22

Naval Research Laboratory
ATTN: Code 2627

Naval Surface Weapons Center
ATTN: Code F31, K. Caudle

Naval Weapons Evaluation Facility
ATTN: L. Oliver

Office of Naval Research
ATTN: Code 465

DEPARTMENT OF THE NAVY (Continued)

Strategic Systems Project Office
Department of the Navy
ATTN: NSP-272

DEPARTMENT OF THE AIR FORCE

Aeronautical Systems Division
Air Force Systems Command
ATTN: ASD/ENFT, R. Bachman
4 cy ATTN: ASD/ENFTV, D. Ward

Air Force Aero-Propulsion Laboratory
ATTN: TBC, M. Stibich

Air Force Materials Laboratory
ATTN: MBE, G. Schmitt

Air Froce Weapons Laboratory
Air Force Systems Command
ATTN: DYV, A. Sharp
ATTN: SUL
ATTN: DYV, G. Campbell

Assistant Chief of Staff
Studies & Analyses
Department of the Air Force
ATTN: AF/SASC, R. Mathis
ATTN: AF/SASB, R. Mathis

Deputy Chief of Staff
Research, Development, & Acq.
Department of the Air Force
ATTN: AFRD-P, N. Alexandrow

Foreign Technology Division
Air Force Systems Command
ATTN: SDBF, S. Spring

Secretary of the Air Force
ATTN: SAFAL, H. Cooper

Strategic Air Command
Department of the Air Force
ATTN: XPFS, B. Stephan
ATTN: XPFS, F. Tedesco

DEPARTMENT OF ENERGY CONTRACTOR

Sandia National Laboratories
ATTN: A. Lieber

DEPARTMENT OF DEFENSE CONTRACTORS

AVCO Research & Systems Group
ATTN: J. Patrick
ATTN: P. Grady

BDM Corp.
ATTN: C. Somers

Boeing Co.
ATTN: M/S 85/20, E. York

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Boeing Wichita Co.
ATTN: R. Syring

Calspan Corp.
ATTN: M. Dunn

University of Dayton
ATTN: B. Wilt

Effects Technology, Inc.
ATTN: E. Bick
ATTN: R. Globus
ATTN: R. Wengler

General Electric Company—TEMPO
ATTN: J. Moulton
ATTN: DASIAC

General Research Corp.
ATTN: J. Cunningham
ATTN: T. Stathacopoulos

Kaman Sciences Corp.
ATTN: D. Sachs

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Kaman AviDyne
ATTN: E. Criscione
ATTN: R. Ruetenik
ATTN: N. Hobbs
ATTN: B. Lee

Los Alamos Technical Associates, Inc.
ATTN: P. Hughes
ATTN: C. Sparling

McDonnell Douglas Corp.
ATTN: M. Potter
ATTN: J. McGrew

Prototype Development Associates, Inc.
ATTN: J. McDonald
ATTN: C. Thacker
ATTN: H. Moody

R & D Associates
ATTN: F. Field
ATTN: A. Kuhl
ATTN: P. Haas